Journal of Athletic Training 2003;38(3):204–208

www.journalofathletictraining.org

A Comparison of Spine-Board Transfer Techniques and the Effect of Training on Performance

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Objective: To compare the log-roll (LR) maneuver and the lift-and-slide (LS) technique and to investigate the effect of training on the performance of these transfer techniques.

Design and Setting: A repeated-measures design involving certified athletic trainers and athletic training students from a National Collegiate Athletic Association Division I college.

Subjects: Certified athletic trainers and athletic training students were required to transfer healthy individuals onto a spine board. Testing was performed on 2 men of average size, whereas training sessions were performed on both men and women of different heights and weights.

Results: Differences between transfer techniques were noted. The execution of the LR produced significantly greater lateral-flexion motion and greater axial rotation of the head as compared with the LS. Performance of spine-board transfer techniques did not improve with training.

Conclusions: The LS technique was more effective in restricting motion of the head. To truly establish the safety of spine-board transfer techniques, researchers need to assess how individual segments move within the structurally unstable cervical spine.

Key Words: cervical spine, spine injury, emergency management

When caring for the patient with a spine injury, it is necessary to restrict movement of the spinal column in order to avoid creating neurologic injuries secondary to those produced by the inciting trauma. The initial step in the prehospital management of a spine-injured patient is to provide manual, inline stabilization.[1–4] This involves maintaining the head and neck in alignment with the torso and serves to prevent structural deviations from occurring within the spinal column.[1,2] Manual stabilization must then be replaced with mechanical stabilization (full spinal immobilization) to ensure that unwanted movements do not occur while in transit. This step is completed by securing the head, neck, chest, and pelvis of the patient to a long spine board.[3] It is only after the patient has been properly secured to the board and the entire spine is supported that transport to the hospital can proceed.[3,5]

Transferring a patient safely from the ground to a spine board in order to achieve full spinal immobilization is not an easy task. To facilitate the completion of this task, rescuers rely on spine-board transfer techniques. These include the log-roll (LR) maneuver and the lift-and-slide (LS) technique. Only by employing these techniques can rescuers provide continuous, inline stabilization of the head and neck while simultaneously transferring the spine-injured patient onto a spine board.

With its simple and straightforward elements, the LR maneuver has long been the most appealing and most widely used transfer technique.[2,6,7] In addition to having minimal personnel and strength requirements, the LR maneuver can easily be modified to handle the potential problems associated with patient position (prone versus supine). In contrast, the LS technique relies heavily on the strength and coordination of the rescuers.[8] Moreover, the LS technique may only be suitable for transferring patients found in the supine position. Despite these limitations, there is some benefit to using this technique when the individual needing to be transferred is wearing protective equipment. That is, the execution of the LS technique avoids rolling the injured patient over bulky pads and is thus extremely effective at minimizing the generation of unwanted spinal-column movement.[8] The National Athletic Trainers' Association (NATA) has published guidelines recommending that the LS (in combination with a scoop stretcher) be used to transfer all athletes found in the supine position, particularly those wearing protective equipment.[4]

It is clear that individuals who are responsible for providing the initial care to potential and actual spine-injured patients must not only be aware of the various forms or techniques used in transferring patients, but they must also be proficient in the execution of these techniques. The purpose of this investigation was to compare the effectiveness of the LR and LS and to evaluate the effect of training on their performance.

METHODS

Participants

Forty-eight qualified individuals were recruited as rescuers for this investigation: 26 NATA Board of Certification–certi-

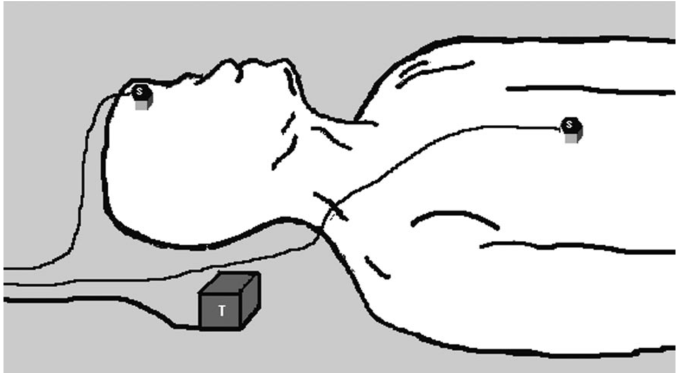

Figure 1. Sensor placement: T = Fastrak transmitter, s = Fastrak sensor.

Figure 2. The log-roll (LR) maneuver.

fied athletic trainers and 22 athletic training students (17 men, 31 women; age = 23.3 ± 3.49 years). In addition, another 26 participants were recruited as transfer subjects (age = 22.1 ± 2.66 years, height = 173.99 ± 9.48 cm, mass = 72.44 ± 12.81 kg). All participants completed an informed consent form approved by the university's institutional review board, which also approved the study.

Instrumentation

We used a Fastrak 3-dimensional tracker (Polhemus Inc, Colchester, VT) to quantify the amount of head motion generated during the execution of both the LR and the LS. The Fastrak device is a noninvasive, 6 degrees-of-freedom tracking instrument that uses electromagnetic fields to determine the position and orientation of its sensors in 3-dimensional space. According to the manufacturer's specifications, the magnetic tracking system functions optimally when the distance between the source (transmitter) and the sensors falls within 76 cm. Beyond this optimal distance, electromagnetic waves decay significantly. Therefore, the transmitter was positioned as close as possible to the sensors to maintain the integrity of the electromagnetic waves. In addition, metal found in proximity to the source of electromagnetic waves may interfere with the magnetic field that is generated. For this reason, all data were collected in a metal-free room, and all participants were asked to remove all digital and metal accessories.

Sensors from the Fastrak device were positioned on the forehead (3 cm superior to the bridge of the nose) and the sternum of the transfer subject (1 cm proximal to the xiphoid process; Figure 1). Hypafix adhesive tape (Smith & Nephew Medical, Massillon, OH) was used to secure the sensors onto the selected landmarks. Each sensor identified and recorded 3-dimensional motion data from its respective location on the body. The amount of head displacement detected using either transfer technique was determined by calculating the angular displacement of the head relative to the sternum. The 3-dimensional displacement data were collected as transverse-, sagittal-, and frontal-plane motion of the head but presented as axial-rotation, flexion-extension, and lateral-flexion motion of the head, respectively.

Before data collection began, we assessed the validity of the Fastrak instrument by comparing angular-displacement values obtained from the unit with those captured by an analog goniometer. The sensors were affixed to the arms of the goniometer as it was moved to 10 randomly chosen angles, and the angular displacements were recorded at each angle with the Fastrak. Pearson product moment correlation coefficients were then calculated to assess the accuracy of Fastrak angular measurements. Additionally, each of the goniometer angles was repeated in random order so that the reliability of angular displacements could be determined. This was calculated using intraclass correlation coefficients (ICCs) for the repeated measurements obtained by the Fastrak device. We then computed dependent *t* tests to determine if the obtained measures were significantly different.

Tests revealed the Fastrak device to be very accurate, with strong correlation coefficients calculated for motion about all 3 axes of rotation ($r = 1.00$). Additionally, dependent *t* tests revealed no significant differences between measures obtained with the Fastrak device and the goniometer. Furthermore, tests of reliability revealed the Fastrak device to be consistent in the ability to measure angular displacement about the x-, y-, and z-axes (ICCs equaled 0.99 in all cases). Again, dependent *t* tests revealed no significant differences among repeated measures obtained with the Fastrak device.

Treatments

Six individuals were needed to perform the specific variation of the LR and LS that we chose to investigate.[9] Both techniques required 5 rescuers to either roll or lift the transfer subject, and a sixth individual to position the spine board beneath the transfer subject.

Log-Roll Maneuver. The 5-person LR required 1 person to provide manual, inline stabilization; 2 to assist in rolling the torso and upper extremities; and 2 to assist in rolling the lower extremities (Figure 2).[9] With the LR maneuver, all 5 individuals took hold of the transfer subject and rolled the individual 90° to the side-lying position. Once the transfer subject was placed in the lateral-recumbent position, a sixth rescuer wedged the spine board beneath the transfer subject (45° to the ground). To complete this technique, the transfer subject was carefully rolled back to the supine position onto the spine board. In most cases, after a patient has been rolled back to

Figure 3. The lift-and-slide (LS) technique.

the supine position it is necessary to make adjustments so that the individual is centered on the spine board. This component of the LR maneuver was not included in this investigation.

Lift-and-Slide Technique. With the 5-person LS, 1 person maintained manual, inline stabilization of the head; 2 lifted the upper torso; 1 lifted the hips and pelvis; and 1 lifted the knees and lower extremities (Figure 3).[9] With this technique, participants responsible for lifting the upper torso kneeled by the transfer subject's shoulder and placed 1 hand beneath the lateral aspect of the shoulder and the other hand beneath the torso, just below the level of the axilla. The remaining 2 people straddled the transfer subject at the level of the thighs and legs. The person supporting the head directed all the other participants initially to raise the transfer subject off the ground and then to gently bring the transfer subject into place on the spine board.

Procedures

In this investigation, each rescuer was randomly assigned to 1 of 8 transfer teams. Each team was required to attend a total of 5 sessions. During the initial session, teams were instructed on proper execution of both transfer techniques with a video presentation developed by the lead author (G.D.R.). Members of each group then selected the position or duty they would perform throughout the investigation. Once the positions were finalized, transfer groups were required to complete up to 3 practice trials of each transfer technique. A pretraining test session followed this familiarization period. Head motion was assessed using the Fastrak device as each group executed 2 trials each of the LR and LS. The order of testing (for transfer technique) was randomly assigned with a coin toss. For the initial test session, only 1 transfer subject was available for all groups.

At the completion of the initial testing session (pretraining), each group was randomly assigned to train either with the LR or the LS transfer technique. As part of their training, each group was required to attend 3 sessions. At these sessions, which took place at least 24 hours apart, each team completed 10 repetitions of the assigned technique. All throughout these training sessions, transfer subjects with different heights and weights were available to all groups. The fifth and final session was a posttraining test session. Again, each group completed 2 trials each of the LR and LS techniques. As with the pretraining test sessions, a single transfer subject (different from the pretraining transfer subject) was available for all groups.

To maximize the response variables of this study (ie, angular displacement in all planes of motion), a cervical collar was not used during the execution of transfer techniques. In a true emergency, it is highly unlikely that a victim would be transferred to a spine board without a cervical collar in place.

Data Analysis

All statistical analyses were performed using SPSS software (version 10.0, SPSS Inc, Chicago, IL). The dependent variables were the maximum total range of angular displacement generated in each of 3 planes of motion (flexion-extension, lateral flexion, axial rotation). The difference in performance between trained and untrained groups was analyzed using the change in the amount of head motion from pretraining to posttraining. All data were analyzed with nonparametric statistical tests because of the violation of the assumption of homogeneity of variance. Mann-Whitney U tests were calculated to compare the LR with the LS technique and to compare performances between trained and untrained groups. In addition, Wilcoxon signed-rank tests were calculated to determine the effects of training on LR and LS performance. In all cases, the a priori level of significance for statistical tests was set at $\alpha \leq .05$.

RESULTS

Log-Roll Technique Versus Lift-and-Slide Technique

The average total range of motion generated in all planes of motion during the execution of both the LR and LS is presented in Tables 1–3. Significant differences between techniques posttraining were noted, with the LR producing more lateral-flexion ($Z = -2.31$, $P = .03$) and axial-rotation motion ($Z = -2.31$, $P = .03$) but not more flexion-extension motion ($Z = -1.16$, $P = .34$).

Log-Roll Performance

Flexion-Extension. No significant improvement in flexion-extension motion was noted with training ($Z = -1.83$, $P = .07$). Also, no significant difference in LR performance was observed between trained and untrained groups ($Z = -1.73$, $P = .11$).

Lateral Flexion. Training had no significant effect on the

Table 1. Mean (SD) Range of Flexion-Extension Motion of the Head (°)

Group	n	Log Roll		Lift and Slide	
		Pretraining	Posttraining	Pretraining	Posttraining
Log roll, trained	4	12.45 (3.41)	9.49 (2.06)	6.37 (1.04)	6.54 (0.93)
Lift and slide, trained	4	12.36 (3.88)	14.25 (1.89)	10.13 (4.62)	7.04 (2.72)

Table 2. Mean (SD) Range of Lateral-Flexion Motion of the Head (°)

Group	n	Log Roll		Lift and Slide	
		Pretraining	Posttraining	Pretraining	Posttraining
Log roll, trained	4	10.13 (3.36)	12.22 (3.48)*	5.07 (1.51)	2.96 (0.46)
Lift and slide, trained	4	11.54 (6.68)	17.94 (5.78)	7.17 (3.81)	4.11 (0.98)*

*$P < .05$.

Table 3. Mean (SD) Range of Axial-Rotation Motion of the Head (°)

Group	n	Log Roll		Lift and Slide	
		Pretraining	Posttraining	Pretraining	Posttraining
Log roll, trained	4	21.89 (5.99)	24.68 (6.24)*	7.38 (0.92)	4.95 (1.03)
Lift and slide, trained	4	15.81 (13.54)	20.91 (7.70)	11.66 (8.00)	6.00 (1.49)*

*$P < .05$.

generation of lateral-flexion motion ($Z = -0.73$, $P = .47$). Additionally, a significant difference in performance was not identified between those who trained with the LR and those who did not ($Z = -0.87$, $P = .49$).

Axial Rotation. The axial-rotation motion generated with the LR did not change significantly with training ($Z = -1.1$, $P = .27$). There were also no apparent differences between trained and untrained groups ($Z = -0.58$, $P = .69$).

Lift-and-Slide Performance

Flexion-Extension. Training had no effect on the amount of flexion-extension motion generated with the execution of the LS technique ($Z = -1.46$, $P = .14$). In addition, there were no differences in performance between trained and untrained groups ($Z = -1.16$, $P = .34$).

Lateral Flexion. The amount of lateral-flexion motion generated after training did not change significantly from the amount generated before training ($Z = -1.46$, $P = .14$). Also, trained and untrained groups did not generate significantly different amounts of lateral-flexion motion ($Z = -0.58$, $P = .69$).

Axial Rotation. No significant differences were identified between the axial-rotation motion generated before and after training ($Z = -1.46$, $P = .14$). As in all other cases, significant differences between trained and untrained groups were not observed ($Z = -0.29$, $P = .89$).

DISCUSSION

Sensors mounted to bony landmarks on the head and sternum allowed us to evaluate the quality and quantity of head motion produced during the execution of commonly used spine-board transfer techniques. Although statistical analysis of our data did not reveal any significant improvements in performance (perhaps a consequence of the small sample size), significant differences between techniques were noted. That the execution of the LR generated greater head motion than the LS was not an entirely unexpected finding. Preliminary research has already revealed that execution of the LR maneuver generates excessive amounts of thoracolumbar motion.[7,10] McGuire et al[10] reported that 30° of angular rotation were produced when the LR maneuver was performed on a cadaver with marked instability of the lumbar spine (L1–L2). In addition, Suter et al[7] noted that performing the LR on healthy individuals produced 15 mm (range, 1–38 mm) of thoracolumbar spine deviation. Needless to say, both groups concluded that the LR maneuver might be unsafe for transferring those with suspected thoracolumbar injuries.

Although the LR is a well-designed transfer technique, its execution presents a considerable challenge to rescuers, which is not at all surprising given its complexity. To maintain manual, inline stabilization as a patient is rolled to the lateral-recumbent position, the head of the patient must come off the ground and proceed through an arc of motion as he or she is rolled 90° to the side-lying position. In the side-lying position, the patient's head must remain aligned with the torso as the spine board is wedged in place. Finally, to complete the transfer, the initial arc pattern must be retraced to return the patient to the supine position on the spine board. In contrast, the LS technique requires that the head move with the body in simple linear fashion as the patient is lifted up vertically off the ground and then positioned on the board.

Attempting to restrict head (and spinal) motion during execution of the LR maneuver may be even more challenging if the slope of the spine changes during the procedure. The concept of a dynamic spinal slope (ie, one that changes during the transfer process) was first proposed by Suter et al.[7] They suggested that a change in the slope of the spinal column may be expected because of the proportional differences between various areas of the body. In particular, Suter et al[7] theorized that shifting a patient to the side-lying position results in a change in the slope of the thoracolumbar spine because of differences in width between the upper and lower torso. Naturally, given the continuity of the spine, a shift in the slope of the thoracic spine could also affect the alignment of the cervical spine. Thus when performing the LR maneuver on a patient with a cervical spine injury, it may be necessary to adjust the angle of the head to accommodate for differences in body proportions.

According to the American Academy of Orthopaedic Surgeons,[11] unstable bony fragments produced by trauma to the cervical spine can jeopardize the spinal cord with even the slightest movement (1–2 mm). To accurately assess the safety of the LR and the LS, it is necessary to investigate how the unstable spine moves during the execution of these techniques. Although the head-displacement data reported in this study have advanced our understanding of the general effectiveness of emergency transfer techniques, they do not provide an accurate indication of how the segments of the cervical spine move during the execution of these techniques. In the future, researchers will need to examine the motion generated between individual vertebrae. In addition, a cadaveric model will be necessary to investigate how transfer techniques affect the structurally unstable cervical spine.

A few specific limitations of this study must be addressed. One is related to the convenience sampling of athletic trainers and athletic training students. Participants recruited for this study were recruited from graduate and undergraduate athletic training education programs. Therefore, participants consisted of young individuals with limited LR and LS experience. Another factor is the limited number of transfer subjects. The build, height, and mass of the transfer subjects used during test sessions prevent the generalization of our results to patients with different structural characteristics.

In summary, head motion was best restricted when the LS technique was used to transfer patients to a spine board. Whether the LS is truly the best technique for transferring victims of cervical spine trauma remains uncertain. To establish the safety of the LR and LS, researchers will need to evaluate how the structurally unstable cervical spine moves during execution of these transfer techniques.

ACKNOWLEDGMENTS

We thank all participants for committing their time to this investigation. We give special thanks to the University of Florida Department of Orthopaedics for providing the Fastrak device used in this study. Also, we are grateful for the contributions of Tim Heffernan to this project.

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